CHILDREN'S KNOWLEDGE AND MEMORY: CORRELATION BUT NOT CAUSALITY

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1988

to

lewis and charlie,

the

loves of my life

ACKNOWLEDGMENTS

Many people helped to insure the successful completion of this study. I thank Pat Miller for guiding me through the intense graduate school learning process. Pat involved me in her research early in my graduate school career, and her enthusiasm for research was contagious! Pat always makes time when her students need assistance and is a very dedicated professional. Pat also showed all of us that a woman can have a serious career and a family simultaneously. She not only was my adviser but a terrific friend as well.

I would like to thank two members of my committee, Scott Miller and James Algina, who taught me about research design and statistics, both in and out of the classroom. Both were excellent teachers and assisted me with numerous questions throughout my graduate school career. I also thank the other members of my committee, Ira Fischler, Rich Griggs, and Robin West, for their support.

I am grateful to Peggy Blitch and the teachers and students at Martha Manson Academy for giving me and my assistants a warm welcome at the school. I also appreciate the numerous occasions that Ruth Duncan and the teachers and students at P.K. Yonge Laboratory School did the same.

Two fellow graduate students rescued me from doom, when I thought making the videotapes would be impossible. Al Avendano had the "know-how" to film and produce them. Pat Aloise narrated them, because I lost my voice on the day the camera was set to roll! The cooperation among graduate students truly makes the program at the University of Florida special.

I was fortunate to have the assistance of several very dedicated undergraduate assistants, who contributed many hours of their time and talents to help make this study possible. Carol Lewald and Rick Anderson helped to test subjects for the study. Kathleen G. Cossey and Carol Lewald coded and scored (and scored and coded!) the data. Others who assisted with various aspects of the study were Randi Clement, Troy Zarcone, Jackie Spiegel, Spencer White, Nikarre Redcoff, and Coreen E. Prochnow at the University of Florida; Lisa Mallet, Jean Muransky, Rose Kramer, Gary Kolvachik, Beth Owen, and Teri Miller at Muskingum College; and Erica Miller, a Sarah Lawrence student-to-be.

Cecil Chapman typed the labels for the birds on, what was then, her brand-new laser printer. Cecil helps everyone, and her cheerfulness makes the developmental/cognition area a brighter place to be.

Bill Hardy was the much-depended-upon ornithologist who helped with the original lists of birds, loaned me slides for the videotapes, and answered, what seemed to be, my 10

million questions about birds. I knew nothing about birds when I began this project!

I thank Larry Normansell, my colleague at Muskingum College, for his assistance in producing a poster version of this paper. The poster for the Conference on Human Development in Charleston was aesthetically pleasing!

I thank David Bjorklund for keeping me informed of his research and sending me a computer program for defining which children were "strategic." I became excited about conducting memory development research after attending a symposium at the Conference on Human Development in Nashville (1985) during which David, Peter Ornstein, and others debated the nature of strategies.

I especially thank Lewis for enabling me to pursue a career. In addition to his generous donation of time assisting with computer questions and problems, Lewis is always helping behind the scenes. I appreciate all that he does.

Thanks to my wonderful graduate school friends of the past: Gillian, Marite, Malia, Vern, John, Terry, Nan, and Carol for providing "kinship." The spirit and warmth of Florida live on in all of us (though most of us have migrated north). Now as another clan of graduate students makes their way up the graduate school rungs, may they keep the spirit of Florida alive: Pat, Maggie, Janet, Nanci, Bob, Al, Wendy, and others. Until we meet again, see you at SRCD!

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Abstract of Dissertation Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

CHILDREN'S KNOWLEDGE AND MEMORY:
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By

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December 1988

Chairperson: Patricia H. Miller
Major Department: Psychology

Previous research on memory development suggests that increases in knowledge during development may encourage strategy use and improve recall. Unlike these correlational studies, the present study tested this hypothesis by experimentally manipulating knowledge.

Knowledge about birds among 44 younger (mean age: 8-7) and 53 older (mean age: 10-5) children was assessed via four tests. 1) GROUPING: Children placed 45 picture/name cards of birds into groups that they thought belonged together, and titled each group. The number of birds placed into meaning-based groups (e.g., pet birds) was tallied. 2) LISTING: Children said all the members they knew for six experimenter-designated categories (e.g., birds of prey, songbirds). 3) FACTS: Children stated all the facts they knew about each of

the birds. 4) MATCHING: Children placed the birds into the six possible categories used for LISTING.

Children's strategies while studying 20 picture/name cards of birds were videotaped, coded, and scored. Depending upon their assigned groups, children took either the four knowledge tests or a memory test both before and after, or they took all tests only after viewing five videotapes about birds. The videotapes, shown in the classroom by the regular classroom teacher, taught information about the birds and emphasized intra-group associations.

Between-subject analyses showed significantly higher knowledge scores after the videotapes than before for both sexes on MATCHING, and for boys only on GROUPING. Within-subject analyses revealed significant improvements on MATCHING, LISTING, and GROUPING. All analyses showed substantial increases in the percentage of facts referring to general, categorical information.

Despite significant increases in knowledge and significant correlations between knowledge and memory, there were not significant improvements in clustering and overt study strategies (e.g., rehearsal). Although knowledge changes were greater overall for males, only the females in the within-subject analysis showed significant improvement in recall. Males' recall <u>decreased</u> significantly. The between-subject analysis showed no improvement in recall for any group.

Either knowledge is not the cause of improvements in memory with age, or knowledge is necessary as a first step, but not sufficient. Possible reasons for correlation but not causality are discussed.

CHAPTER I
INTRODUCTION

The Beginning of Research Related to Memory

The study of memory is a topic that has intrigued psychologists for more than 75 years. One of the earliest, and most famous, studies of memory was conducted by Hermann Ebbinghaus, a German psychologist. Ebbinghaus invented the nonsense syllable and used himself as a subject. His measure of memory was that of relearning, the time it took to relearn a list of nonsense syllables to perfection, after various intervals of time (Ebbinghaus, 1913).

Although other studies appeared during the first 60 years of the 20th century, that period has been described as a "long period of misdirection, confusion, and sterility" (Olson, 1983). However, the study of memory blossomed in the late 60s, and new methodology facilitated its study. Introspection, which was dominant in this country during Ebbinghaus' time, was no longer considered a scientific method. The information processing approach has prevailed since the 1960s.

Research related to the development of memory flourished following a landmark symposium, organized by John

Flavell, which took place at the biennial meeting of the Society for Research in Child Development (SRCD). The title of this 1971 symposium was "What is memory the development of?" At the 1981 SRCD symposium which marked the ten-year anniversary of Flavell's symposium, Trabasso (1983) remarked that the answer to the general question "What is memory the development of?" depends on one's answer to "What is memory?" Our conceptions of what memory is have changed since 1971, and so have our conceptions of what is developing, but no one to date has been able to answer Flavell's challenging question with certainty.

Review of the Literature Investigating the Answer to: "What Is Memory the Development of?"

Over the past 20 years, several answers to the question "What is memory the development of?" have appeared in the literature. One answer was that capacity developed (Pascual-Leone, 1970). However, that answer has been challenged in more recent reviews of the literature (Dempster, 1981, 1985) and will not be discussed in this paper. Another answer offered is that metamemory (i.e., children's understanding of the memory process) develops (Pressley, Borkowski, & O'Sullivan, 1985; Rao & Moely, 1987). That line of research also will not be examined in this paper, because it is not directly related to the present study. Two other answers to the question have received the most attention. They are that

strategy use develops and that knowledge develops. Each of these will be discussed.

Strategy Use Develops

One of the answers to the question "What is memory the development of?" was emphasized by several presenters at the 1971 symposium and still is being researched today. That answer is that strategy use develops. Theoretical models from the 1970s and up through the early 1980s (if not longer) also emphasized strategies (Ackerman, 1987).

In 1970 an influential article by Flavell proposed that younger children have a production deficiency. That is, younger children typically do not employ strategies for remembering (e.g., rehearsal) spontaneously. However, if younger children are instructed to use the strategy, their recall rises to the same level as older children, who spontaneously produce the strategy.

A surge of research investigated that hypothesis. Improvements with age in strategies such as rehearsal (e.g., Flavell, Beach, & Chinsky, 1966; Ornstein, Naus, & Liberty, 1975); clustering (e.g., Moely, Olson, Halwes, & Flavell, 1969; Moely & Shapiro, 1971); organization (e.g., Corsale & Ornstein, 1980; Kee & Bell, 1981); and elaboration (e.g., Pressley, 1982; Pressley & Ross, 1984) are well documented. Training studies also reliably show that younger children benefit by brief instruction in rehearsal (e.g., Naus,

Ornstein, & Aivano, 1977; Ornstein, Naus, & Stone, 1977); clustering (e.g., Moely et al., 1969); organization (e.g., Bjorklund, Ornstein, & Haig, 1977; Moely & Jeffrey, 1974); and elaboration (e.g., Pressley et al., 1985).

An example of a study from this period follows. This study by Moely et al. (1969) was interpreted as confirming that younger children have a production deficiency. Children in grades 1, 3, and 5 were presented with 16, 20, or 24 pictures of categorically related items (i.e., 4, 5, or 6 items from the categories of animals, furniture, vehicles, or clothing) to study for two minutes. There was greater categorical organization with increasing age. Although there was little change between grades 1 and 3 in the children's study and recall organization, there was a sharp increase in both measures between grades 3 and 5. An instructions condition, during which children were asked to sort the items "that go together or are alike" (p. 28), facilitated the performance of all children. Furthermore, after recall, when nonsorters (children who had not been instructed to sort) were asked to sort the pictures, 58%, 74%, 88%, and 95% of the kindergarten, first, third, and fifth graders, respectively, were able to sort the cards according to their category membership. Thus, nonsorters were able to sort. The fact that these young children were able to sort cards according to category membership was interpreted to mean that

they possessed the necessary knowledge about categories, but simply did not use it.

Much like the Moely et al. study, the other studies of this period seemed to confirm that although younger children (i.e., children in grades 1 to 3) often did not utilize the appropriate strategies spontaneously, they easily could be taught to use them, and consequently, benefited from them. By grades 5 to 7, children employed strategies spontaneously and successfully.

More recently, several aspects of the production deficiency hypothesis have been questioned. Chi and Ceci (1987) challenged the assumption that young children have the relevant knowledge about categories but simply do not use it. Although the young children in the Moely et al. study (as well as other studies of that period) were able to successfully complete sorting tasks, and the researchers claimed this was evidence that the children had the necessary knowledge, Chi and Ceci suggested that children's knowledge simply may not be in a readily usable form. They gave the example that picking pictures that belong to the category "animals" only requires a child to know whether the attribute of "animalness" goes with each item. They believe that this type of knowledge is different from the knowledge needed to link elements to a unified superordinate structure. That is, a child who can sort or match may have a representation that is not a categorical structure.

Therefore, the child's and adult's representations of knowledge still might differ dramatically with respect to organization, and these differences might make the knowledge less available to children.

Rabinowitz (1984) has argued for the importance of differentiating between whether young children do not use available knowledge because they prefer not to use it or because it is less accessible to them. Although the traditional notion of production deficiency claimed that young children were predisposed to use strategies (such as repeating a word over and over) that were less effective in helping them recall, Rabinowitz suggested that those strategies might be more easily accessed than one of organizing words by semantic meaning. He demonstrated that children use categorical processing more effectively when the list contains highly representative items from the categories.

A second question concerns the way in which strategies develop. Several studies stimulated by the production deficiency hypothesis have demonstrated what appear to be strategic behaviors by preschoolers (e.g., Baker-Ward, Ornstein, & Holden, 1984; DeLoache, Cassidy, & Brown, 1985; Wellman, in press). This might seem to challenge the claim that young children do not spontaneously produce strategies. However, these occur only in specific, supportive contexts. It is not clear how and why early strategic behavior emerges

(see also a review by Daehler & Greco, 1985), and how it relates to mature strategy use, which appears to be more general. Researchers currently are debating whether earlier strategies are deliberate and intentional or relatively unconscious and automatic. This and other debates in the field will be addressed in a later section.

Even if younger children produce the same strategy as older children, it may be, as suggested in a study by Guttentag (1984), that strategy use is more effortful for younger children. This may account for the observed lags in the facilitative effects of early strategy use for younger children (e.g., DeMarie-Dreblow & Miller, 1988; Miller, Haynes, DeMarie-Dreblow, & Woody-Ramsey, 1986). These children spontaneously produce an appropriate strategy, but it does not help them, a phenomenon that Patricia Miller has labeled a "utilization deficiency" (Miller & Harris, in press). If producing a strategy is quite effortful for young children, there may be little capacity remaining for subsequent processing of the material to be remembered. Thus, as these studies illustrate, clarifications of the mechanisms by which strategies develop are necessary.

Although debates exist as to the development and nature of strategies, probably no one in the late 1980s still believes that strategy use alone can explain what develops when memory develops. Another view of memory development, which is receiving greater and greater attention from

researchers, suggests that knowledge plays an important role in memory development.

Knowledge Develops

A study by Chi in 1978 posed a major challenge to the field of memory development research. She showed that when younger children had more knowledge of a domain (e.g., knowledge of chess) than adults, the superiority of the older subjects, typically found in other studies, was absent. In fact, the 10-year-old children in Chi's study (who were chess experts) recalled more chess piece positions from immediate memory and took fewer trials to recall all chess piece positions, than the adults (who were chess novices). The children also retrieved a greater number of chunks than the adults for the first trial. On the other hand, Chi found the more typical adult superiority for a digit span task. She proposed that knowledge of the specific content area was more important than general strategies in determining memory performance. Thus, Chi's answer to the question "What is memory the development of?" was that knowledge develops.

A study by Lindberg (1980) found similar results. Third graders and college students were tested for recall of two different lists, each containing 30 words. One list was a typical experimental list that contained words from Battig and Montague category norms. The other list contained words generated by three third graders. These words were assumed to

be highly familiar to third graders. An example was the members of the television show "Charlie's Angels," something of importance to most third graders in 1980! Although the college students clustered and recalled more of the words typically used in experiments, the third graders clustered and recalled more of the words that were more salient to them. Again, a reversal of the traditional superiority of adults seemed to show that knowledge of the stimuli was an important aspect of memory development.

This wave of research in the late 70s and thus far in the 80s has attempted to define the role of knowledge in memory performance. Differences in knowledge were said to be responsible for both differences in the production of a strategy (e.g., rehearsal) and memory per se in a study by Naus and Ornstein (cited by Zembar & Naus, 1985a). Naus and Ornstein tested two groups of adults (soccer experts and soccer novices) for recall of two different lists of words (a typical experimental list and a list containing soccer-related items). Although there were no significant differences between the two groups for recall and size of the rehearsal set (i.e., the average number of different words rehearsed aloud per inter-item interval) for the typical experimental list, the soccer experts were superior on both measures for the soccer-related item list. Because adults presumably already have sophisticated memory strategies

accessible to them, the results were attributed to the differences in knowledge of the materials for recall.

Likewise, a study by Zembar and Naus (1985b) found differences in the level of strategy use and recall, depending upon the materials. They gave third graders, sixth graders, and adults lists that varied in familiarity to them and found corresponding differences in rehearsal strategies and recall. When third and sixth graders were studying a list that was very familiar to them, they used a more sophisticated rehearsal strategy (i.e., rehearsing a greater number of different items together) than when they were studying a list that was less familiar to them. An interesting result in this study was that the third graders' rehearsal and recall of the easiest list was almost identical to the sixth graders' rehearsal and recall of the typical experimental list. On the other hand, the sixth graders' rehearsal and recall of an advanced adult list was as poor as the third graders' rehearsal and recall of the typical experimental list. Thus, these studies suggested that knowledge of the materials to be learned could influence the use of strategies, which then could influence memory performance.

In the words of Zembar and Naus (1985a):

> In a "short-term" fashion, the available empirical evidence suggests that age-related changes in knowledge can affect the ease with which strategies are employed by modifying the actual content in knowledge as well as increasing the ease by which information can be accessed. (p. 7)

It has become obvious to researchers investigating memory development in the 1980s that no single, simple answer to the question "What is memory the development of?" is likely to be found. It appears to be more and more likely that knowledge and strategies interact. Recently, researchers have begun to debate several aspects of strategy usage and knowledge. Because these provide a context for the current study, they are explored in the next section.

Current Debates in the Field of Memory Development

Accompanying the important question of what is developing are recent debates about various issues concerning the nature of strategies and knowledge. One debate concerns whether strategy use during the grade school years is deliberate and intentional or automatic and unconscious. Another debate concerns the nature of knowledge and why greater knowledge may facilitate the use of strategies. Discussions of both follow.

Currently, the main debate concerning the nature of strategies and their use is between Peter Ornstein and David Bjorklund. Ornstein, Naus, and others take the position that strategy use develops much like skills develop (see Ornstein, Baker-Ward, & Naus, in press; Zembar & Naus, 1985a). They believe that the cognitive operations required for the successful deployment of strategies gradually become more routinized. As this happens, strategies require less and

less capacity with age, and, consequently, during development they facilitate children's performance to a greater extent when they are employed. Ornstein, Naus, and others also distinguish between strategies at input (e.g., rehearsal and organization) and strategies at output (e.g., clustering). Finally, they claim that even preschoolers show strategic behaviors when learning very familiar material, and that even these behaviors may be intentional and deliberate.

Bjorklund, on the other hand, disagrees with the position of Ornstein, Naus, and others. He believes that strategy use, and particularly the clustering that typically is observed in children's recall, is not deliberate until early adolescence (see Bjorklund, 1985). He claims that the clustering typically observed in younger children's recall is due only to the automatic activation of associated words in memory. This position also was taken by Lange (1973,1978), who included lists that minimized the associativity of words and found that younger children's clustering was no longer at above-chance levels.

Other evidence for that position came from research by Bjorklund and Zeman (1982,1983). When children in first, third, and fifth grades were asked to recall their classmates' names (information that is quite familiar to them), memory performance was high for children of all ages. Although clustering (i.e., organizing recall by seating in the classroom, reading groups, race, or sex) also was at a

high level, the majority of children were not able to state what strategies they had used to remember the information. This was taken as evidence that early clustering is based upon associative relations, and that strategies later are discovered when subjects notice patterns of their own retrieval.

Consistent with Bjorklund's position is the finding that grade school children, who appear to be clustering at above-chance levels, in fact do so minimally. Frankel and Rollins (1982) attempted to explain why children who are under eight years of age who had above-chance clustering did not necessarily have enhanced levels of recall. Whereas the younger children's recall typically consisted of isolates or of only two intracategory items, adults' recall consisted of category strings, with as many as five or six items per string. The results were interpreted as evidence that the organization of children's and adults' recall differs dramatically, and that children's clustering in recall may be associative rather than categorical.

Bjorklund (1987) proposes that a major developmental change is the increased frequency of occurrence of particular items. He argues that more frequent exposure to certain items probably causes an increase in the number and type of features and creates more links with other items in semantic memory. This, he believes, is largely responsible for the changes with age in the ease with which semantic memory items

can be activated. In a more recent review of the literature, Bjorklund and Muir (in press) further suggest that when items in semantic memory can be activated more easily, children have more mental capacity available for other cognitive operations (e.g., memory strategies). Bjorklund (1987) also cautions that one must be careful not to define the term "knowledge" too broadly when referring to differences in knowledge base across ages.

The Definition and Measurement of Knowledge

Although the focus of many current studies of memory development is on differences in knowledge, very few have given much attention to a) quantifying the knowledge or b) comparing the recall of individuals with moderate differences in knowledge. Many studies simply classify individuals as experts or novices (Chi, 1978; Gobbo & Chi, 1986; Naus & Ornstein, cited by Zembar & Naus, 1985a), neglecting the relative degree of knowledge present. Although the knowledge differences in which developmentalists are interested primarily are those involving a moderate variation in type or degree, most studies investigating knowledge effects define knowledge in terms of only two points on the continuum, typically very advanced or very elementary knowledge. Saarnio (1987) claims that studies of this nature inflate the role of knowledge. During the tenth anniversary symposium of Flavell's 1971 symposium, Olson (1983) noted

that there still were several important clarifications to be made in the field of memory development, one of which was to determine more subtle differences between experts and novices, beyond the obvious one that the expert knows more about the topic than the novice. There may be qualitative changes (i.e., changes in organization) occurring that go beyond the simple differences in amount of knowledge when expertise reaches the highest level, but this cannot be determined unless attempts first are made to quantify knowledge.

Other studies compare words that are presumed to be more familiar to one or more groups than others (Lindberg, 1980; Zembar & Naus, 1985b) or compare recall for more typical versus atypical members of categories (Bjorklund, 1988; Bjorklund & Thompson, 1983; Buchanan & Bjorklund, 1988). All of these studies measure knowledge at two points at the upper end of the continuum, that is, knowledge that is extremely or moderately well-learned. Again, knowledge has not been measured along a continuum. Therefore, the challenge for memory development researchers in the 1990s will be to specify exactly what is meant by knowledge and exactly what are the actual mechanisms by which memory improves. Very few studies have attempted to examine the contents of knowledge to date.

One study quantified the meaningfulness of three letter nonsense syllables (trigrams) by having subjects generate as

many associations for each as possible. Differences in recall also were measured. It was found that differences in recall could be explained by differences in meaningfulness (Richman, Nida, and Pittman, 1976). However, because the recall test consisted of non-words, it is difficult to generalize the results with certainty. Using a similar measure but with real words (i.e., requiring adults to generate as many facts as they knew for each of 45 birds), DeMarie-Dreblow (1988) found a different outcome. Degree of meaningfulness did not correlate significantly with adults' recall for birds.

Chi and others conducted research specifically designed to describe the structure of knowledge in memory. For example, Chi and Koeske (1983) compared the knowledge structures of two subsets of a knowledge domain that one child possessed. They utilized the model of memory proposed by Collins and Quillian (1969), which assumes that concepts are stored in memory as nodes on an associative network, and relations between concepts serve as associative links. Their subject, a 4 1/2 year old boy, was an expert on the subject of dinosaurs. They compared the way that familiar dinosaurs were structured in his memory to the way that less familiar dinosaurs were structured.

The first task entailed having the child generate all the names of dinosaurs he could. He produced 46 distinct names over a two week period. Next, the experimenter and

child switched roles in a clue game, during which one person told a list of properties and the other had to identify the dinosaur which possessed those properties. Then, two lists of 20 dinosaurs were presented at the rate of one word every three seconds for the recall task. Finally, one year later, a recall naming task was presented to test his memory. The child was shown pictures of dinosaurs and asked to name them.

Chi and Koeske's results showed that the dinosaurs that were more familiar to the boy had a greater average number of links associated with each one, and that these dinosaurs had a greater number of intra-group links with very few, if any, inter-group links. Whereas the boy recalled 10, 8, and 9 dinosaurs across trials from the more familiar list, he recalled only 6, 4, and 3 dinosaurs from the less familiar set. One year later, the boy named 11 of the 20 familiar dinosaurs when shown picture cards, but named only 2 of the 20 less familiar dinosaurs correctly. Chi and Koeske concluded that the observed differences were due to the difference in the structure of knowledge in semantic memory. They suggested that the knowledge of the more familiar set of dinosaurs was more cohesive.

Although this study measured both knowledge and memory, there was only one subject. Therefore, it is difficult to generalize these results with any confidence to all children, or to be certain that they explain memory development in general.

In another study, Gobbo and Chi (1986) utilized production and sorting tasks to compare the underlying knowledge structures of five experts and five novices in the domain of dinosaurs. Expertise was determined via a pretest, and all children were seven years old. For the production task, children said the name of each pictured dinosaur and told everything they knew about it. The number of explicit propositions (i.e., propositions based solely on information that could be gained from the picture) versus implicit propositions (i.e., propositions that gave interpretations or made reference to information that could not be directly observed in the picture) was determined from the children's protocols. Whereas the two groups did not differ in their use of explicit propositions, the experts used a significantly greater number of implicit propositions than the novices. Furthermore, on the sorting task, experts were less likely than novices to group the dinosaurs on the basis of explicit physical features. Instead, experts tended to group the dinosaurs on the basis of combinations of attributes, resulting in family distinctions in many cases.

Gobbo and Chi emphasized that experts and novices differ in their representations, particularly in that experts tend to focus on "deep-level," rather than "surface-type," features. Experts' knowledge also tends to be more structured and cohesive. Chi and Koeske suggested that these differences in knowledge are responsible for the differences

that have been observed in the way experts and novices use their knowledge. However, neither a memory test nor any measurement of strategies was included in this study, so it is difficult to relate these results to issues of memory development.

Although Chi (1985) interpreted the recall differences in the Chi and Koeske study as resulting from domain-specific strategies, Ornstein and Naus (1985) cautioned that the study neither defined nor measured particular strategies. Furthermore, they claimed that it is important to differentiate the contents of knowledge from the ease with which that knowledge can be retrieved from memory. Current research does not differentiate between these two aspects of a knowledge base. In fact, there have been no systematic studies of relations among knowledge, strategy use, and memory.

Purpose of this Study

Many aspects of this study differed from previous studies of memory development. These differences were as follows.

1. Previous research was correlational (i.e., examined relations between memory and pre-existing differences in knowledge). In contrast, this study examined the claim that knowledge causes improvements in strategy use and memory by experimentally manipulating knowledge (i.e., constructing new

knowledge). To the writer's knowledge, this is the first experimental test of that hypothesis. Because correlation need not imply causality, such a test is essential. After pretests for knowledge of, or memory for, birds, knowledge was manipulated by showing children videotapes about birds. If the claims of previous research are correct, then increases in knowledge should be accompanied by increases in both study strategies and recall.

2. Previous research did not measure knowledge along a continuum, but instead tended to select subjects who represented the endpoints (i.e., experts and novices) of knowledge. In contrast, this study measured moderate levels of knowledge.

3. Previous studies generally included only a single measure of knowledge. However, as is clear from the debate on the nature of knowledge described earlier, there may be different aspects of knowledge, which may differ in their effects on memory. Thus, this study included four different knowledge tests, each of which quantified knowledge.

The first test was similar to the sorting task utilized by Chi and Koeske (1983). Children were asked to group birds that were alike or went together in some way. Based on Chi and Koeske's differentiation between explicit and implicit propositions, this study included a count of the number of birds that were placed into meaning-based groups (i.e., groups formed on the basis of information that could not be

obtained by information that appeared in the pictures of birds).

The second knowledge test was similar to the measure of production in Chi and Koeske's (1983) study. Children were asked to generate as many birds as possible that belonged to each of six different experimenter-designated categories. The total number of birds correctly generated by a child for these categories was tallied.

The third knowledge test was similar to Richman, Nida, and Pittman's (1976) measure of meaningfulness. Children were asked to generate as many facts as they knew for each bird. The total number of correct facts generated by a child and the total number of birds for which a child knew at least one fact were calculated. Then, the nature of the generated facts was examined to determine whether a larger percentage of the facts referred to more general, categorical information after children watched the videotapes.

The fourth, and final, knowledge test was a matching test. Children decided to which of six categories each bird belonged. This test only required knowledge of which category "attribute" best described each bird, so it was similar to the measures of knowledge reported in early research on children's use of organizational strategies (e.g., Moely et al., 1969).

4. Although researchers claim that the structure of knowledge may influence the way that knowledge is used,

again, no one has tested that hypothesis experimentally. For example, Gobbo and Chi (1986) found that experts had more intra-group and fewer inter-group connections in memory than novices. They hypothesized that the fact that experts' knowledge was more tightly structured might make that knowledge more accessible to them.

The domain of birds was chosen because it seemed to be an area about which everyone would know something. Yet, knowledge of birds was expected to be highly variable, with some individuals knowing quite a bit and others knowing very little. Therefore, it appeared to be an area in which knowledge would fall along a continuum. Also, birds can be classified on a simple physical (e.g., size of beak) or more conceptual basis, much like the dinosaurs were in the work of Chi and others.

In this study, videotapes about birds were shown to children to attempt to create knowledge that was more tightly structured. Lessons about birds taught intra-group associations (i.e., associations were made between that bird and two other members of the bird's group) in an effort to see if creating the stucture of that type of knowledge would facilitate strategy usage.

Much as in Lange's studies (1973, 1978), the associativity of words on the recall lists was minimized by not placing words commonly clustered by children and adults in pilot research on the same list. Therefore, this would

reduce the words clustered due to their associativity and enhance the possibility of detecting clustering due to category relatedness. In turn, any changes in clustering would more likely be due to the teaching about birds on the videotapes. To insure that any improvements would not be due only to experience with particular items, children received a different list to recall on the pretest and posttest.

5. Most of the previous research focused upon knowledge, or a single study strategy, and recall. To date, no systematic study of all three (knowledge, strategy use, and recall) has been conducted with a large number of subjects.

In this study, children in grades 2 through 5 participated. Previous research suggests that children begin to use more active study strategies sometime during those years. Children were videotaped during the study time for the memory test, and several overt study strategies (i.e., rehearsal, self-testing, and involvement with the cards such as touching or moving them) were identified. In addition, a measure of clustering during recall was assessed. Like other studies (e.g., Moely et al., 1969), the memory test was a recall test. After children studied 20 picture cards of birds for two minutes, they were asked to recall them in any order. Thus, this study was comprehensive and included measures of knowledge, memory, clustering, and study strategies.

Hypotheses

There were three major hypotheses in this study. The first hypothesis concerned the measurement of knowledge. It was hypothesized that knowledge, as measured by each of the four knowledge tests, would improve significantly after the children watched the videotapes about birds.

Second, as mentioned previously, current theories suggest that changes in knowledge may be responsible for improvements in both strategy use and recall with age. If this were the case, then improvements in knowledge should be accompanied by more active use of study strategies, and improvements in clustering and recall. If changes in strategy use and recall were not found, that would question whether there was a causal relation between knowledge and memory.

Whether or not strategy use and recall improved significantly, the third hypothesis was that there would be positive correlations among knowledge, strategy use, clustering, and recall. This would support previous research. However, whether the relation among them would change with age was not known.

CHAPTER II
METHOD

Subjects

Parent permission letters were sent home with 124 children attending a private school in Gainesville, Florida. As suggested by the fact that the tuition for one year was in excess of two-thousand dollars, the children generally were from middle-or upper-middle class families. Nearly all were white.

Parents of 97 children consented to participation in the study. There were 9 males and 12 females from second grade (mean age: 8-1), 14 males and 9 females from third grade (mean age: 9-2), 14 males and 18 females from fourth grade (mean age: 10-1), and 11 males and 10 females from fifth grade (mean age: 11-1).

Each classroom teacher rated her students' ability to learn in school by assigning a descriptive number from one (low) to three (high). Children within each grade, sex, and achievement rating were assigned randomly to groups with the constraint that each group contain children with approximately equal mean ratings.

Materials

Picture cards were utilized for the memory and grouping tests. Each of the 45 three by five inch cards contained a black line-drawing of a bird in the center and a label with a single word naming the bird at the bottom (e.g., "owl" for great horned owl). Because all birds' pictures were black and white and were drawn to be approximately the same size, there were no size or color cues provided by the cards.

The picture cards for the memory test had a pale blue background, and the naming-label appeared on a small, white strip. The picture cards for the grouping test were xerox copies of the others. Thus, these were only black and white.

Pilot testing of children in grades 3 to 6 at a different school was conducted in order to develop two different lists of 20 birds (see Appendix A) to be used for the memory test. Based on the pilot data, these lists had approximately the same probability of recall. In addition, birds that tended to be clustered together by college students (determined by other pilot testing) were placed on different lists. With lists that contained few commonly clustered words, the effect of instruction (giving additional knowledge of birds) upon clustering could be examined more clearly. Each list contained the same number of members (i.e., three or four) that could be classified in each of the six categories. The birds belonging to each of the six categories were determined by an ornithologist at the Florida

Museum on the campus of the University of Florida. Thus, children who took the memory test twice received different (but approximately equal) lists of words, and any improvement in recall would not simply be due to recalling the same list twice.

Children's study strategies during the memory test were videotaped with a Sony Camcorder attached to a tripod in a corner of the room, approximately 7 feet from the table at which children sat. There was no monitor. A stopwatch timed both the study period and the time for computing math problems. Children's responses during the memory test and the facts test were tape recorded.

A yellow tagboard strip was utilized for the matching test. This strip contained one representative picture for each of the six categories and keywords for each category label (e.g., a picture of waves and "live by the water" or a picture of a place setting at a dinner table and "people eat").

Five 10 to 15 minute videotapes (VIDEO) taught facts about 34 of the 45 birds (see Appendix B). Only a subset of the tested birds were taught, so that the other birds could serve as a control set. Analysis of the control set would help to reveal the source of changes in children's performance on the tests. If no improvement occurred in the control set, then improvements in the set of birds that were taught probably were due only to the videotapes. However, if

improvements were noted on the control set, that might suggest that taking the tests alone improved children's performance.

A graduate student filmed pictures of slides with the Sony Camcorder, while a female graduate student narrated the lessons. Thus, these videotapes were of the "home video" variety.

A brief, general introduction to birds was provided at the beginning of the first videotape. A brief introduction to each of the six categories was given before the first member of that category was introduced. Thereafter, no two birds from the same category were taught consecutively, and there was no explicit teaching of all the birds belonging to any specific category. Because this was the first experimental investigation of the hypothesis that increases in knowledge (via additional intra-group associations and a greater number of connections per bird in semantic memory) cause improvements in memory, it was important not to explicitly teach the categorical structure. If children had not been required to do any construction of knowledge themselves, any improvements in memory would appear trivial.

The format for teaching about each bird was similar. Each segment began by telling how that bird was similar to the one in its category that most closely preceded it. Many facts about the bird's habitat, nesting, migration, food, mating, song, or peculiar habits were told during the lesson.

Similarities and differences between that bird and its two category members that preceded it most closely were given during the lesson, and the lesson ended by explaining something unusual about that bird, giving a reminder about the bird, or telling a funny story about that bird (see Appendix C for sample lessons). The sources consulted for information about birds were books (Bull & Farrand, 1977; Peterson, 1947; Robbins , Bruun, & Zim, 1966; Steward, 1977; Zim & Gabrielson, 1956) and an ornithologist.

Other cues were provided during the teaching of some of the categories. Songbirds' songs were audible during entire lessons on songbirds. Pictures of water birds always showed the bird on, near, or over the water. Nightbirds' sounds were played briefly sometime during the lesson, and either their pictures had a dark sky, or the bird was shown camouflaged among its natural surroundings.

Design

Two groups took four knowledge tests or a memory test both before and after viewing the videotapes about birds (see Table 2-1). A third group took the memory and knowledge tests only after viewing the videotapes. This design permitted assessment, with appropriate controls, of both within-subject and between-subject changes in knowledge, memory, clustering, and strategy use.

TABLE 2-1

Testing Sequence for Three Groups of Children Tested for Their Memory and/or Knowledge of Birds

Group	Pre-VIDEO		Videotapes	Post-VIDEO	
	Memory Test	Knowledge Tests		Memory Test	Knowledge Tests
Knowledge Test Only		x	x		x
Memory Test Twice	x		x	x	x
Posttest Only			x	x	x

Within-subject analyses for changes in knowledge compared pretest versus posttest scores on the grouping, listing, facts, and matching tests of the Knowledge Test Only group. Within-subject analyses for changes in memory, strategy use, and clustering compared the pretest versus posttest scores of the Memory Test Twice group.

Between-subject analyses for differences in knowledge compared the Knowledge Test Only group's pre-VIDEO grouping, listing, facts, and matching test scores with the other two groups' post-VIDEO scores. Finally, between-subject analyses for differences in memory, strategy use, and clustering compared the Memory Test Twice group's pre-VIDEO scores with the Posttest Only group's post-VIDEO scores.

The Posttest Only group was included to insure that pre-VIDEO testing was not biasing the results. It also was

important to include it in order to generalize the results with confidence to other laboratory experiments. In other experiments, subjects typically come to the laboratory with pre-existing knowledge. Therefore, it was important to be able to show that children's memory for birds and knowledge of birds was not simply changing because of a practice effect of taking the same tests twice.

Thus, there were two reasons for designing the study to include both within- and between-subject analyses. One was the need to include particular controls for repeated testing. The second was to facilitate the comparison between this study, which attempted to construct knowledge, and previous studies, which examined pre-existing knowledge.

Procedure

All children were tested individually. Children gave their answers for all questions aloud, and the experimenters tape-recorded and/or wrote what each child said on the data sheets. No tests had time limits.

The memory test lasted approximately 10 minutes per child. The knowledge tests were administered in a different session, which always followed the memory test, if it were given, and took approximately 35 minutes per child. Most children were tested for both memory and knowledge on the same day, but for practical reasons several were given the knowledge test the day after they took the memory test.

One male undergraduate student administered all of the memory tests, and one female graduate student administered all of the grouping and listing tests. Finally, one of two female undergraduates, depending upon each one's availability, administered the facts and matching tests.

During the first week, children were tested either for their memory for a list of birds via a recall task or for their knowledge of birds via four different tasks. After three additional weeks had passed, children were shown the five videotapes, one per day, in their classroom by their classroom teacher. Finally, post-VIDEO tests were administered the following (sixth) week.

Memory Test

Children entered a small room inside an office complex at their school. The experimenter introduced himself and told them what they would be doing. He explained that the children were being videotaped, so we could compare how they played the game to how other children played the game.

Two pieces of black tagboard sandwiched the array of 20 picture cards. There were four cards per row and five cards per column. Only the corners of the cards touched.

The experimenter lifted the tagboard, to reveal the picture cards, and instructed children to read the name of each bird once aloud. If a child mispronounced a bird's

name, the experimenter pronounced it correctly. Then, the tagboard was replaced.

The experimenter instructed children to study the birds in any way they wished for two minutes. He also told them (and demonstrated to them) that they could move the cards around if they wished. Half of the children studied the cards for List A and the other half studied List B. After two minutes of study time, the experimenter closed the top of the tagboard, so no cards were visible. To eliminate the recency effect, children received a sheet of math problems, which contained simple addition problems without carrying that they computed for 30 seconds. When the experimenter said "stop," they were instructed to say as many birds' names as they could remember in any order. After 15 seconds of silence, the experimenter said, "Can you remember any other birds?" After an additional 15 seconds of silence, the testing session ended.

Knowledge Tests

1. Grouping. Before going to a child's classroom, the experimenter shuffled the picture cards and placed them randomly into five rows with nine cards in each row on a table at which the child would be seated. No more than two cards from the same category ever appeared consecutively in either direction. Children walked with the experimenter to the room, which was upstairs in a loft at their school

library. While they were walking, the experimenter introduced herself and said:

> We're interested in what kids your age know about birds. You're going to be doing four different activities. We have been doing these activities with adults and find that they don't know very much about birds, so don't be upset if there are birds you've never heard of before.

When they reached the room, the experimenter explained that the first activity was to decide which of the birds were alike or went together in some way. She told children to read each bird's name aloud as quickly as possible and assisted them with names they could not pronounce.

As children gave the experimenter birds they thought belonged together, she wrote them on a data sheet. Then, after asking the children how they thought the birds were alike or went together, she wrote the children's chosen title for the group on the data sheet too. This procedure continued until children had eight groups of birds, used all 45 birds in groups, or could not think of any other groups for the remaining birds, whichever came first.

2. Listing. After children completed the grouping task, the picture cards were removed from the table, and they heard the directions for the listing task. The experimenter said "Tell me as many birds as you can think of that are _____". One of the following six categories was read: birds of prey, birds people eat, talking birds, birds awake at night, birds that live by the water, and songbirds, in that order. The experimenter wrote all the birds children said under the

appropriate category on the data sheet. Children were prompted by the experimenter after 15 seconds of silence. After an additional 15 seconds of silence, the experimenter said the next category. This procedure continued for all the categories.

3. Facts. After the children completed the listing task, the experimenter thanked them for doing those activities and introduced them to another female experimenter, who explained the facts task. Children received three lists of birds counterbalanced for order. (Each column of Appendix D was printed on a separate piece of paper, so the order could be changed.) They said each bird's name aloud into a tape recorder, and then said as many facts as they knew about the bird. If they did not know any facts about that particular bird, they were instructed to say "don't know." The experimenter told them not to guess, only to say facts, and not to spend too much time thinking about a bird.

4. Matching. After children completed the facts task, the experimenter explained that they would be matching birds and categories for the final activity. After placing the tagboard strip on their lap, she told the children the names of the six categories, simultaneously pointing to each one, in turn, on the tagboard display. The experimenter read the names of birds from a data sheet (see Appendix E), and wrote the numbers that represented each category, as children responded. Children pointed to the category to which they

thought each bird best belonged. They were told to guess if they did not know a bird.

The four knowledge tests always were given in this order: grouping, listing, facts, and matching. The grouping test had to be first, so that children would not be biased in their groupings of birds by the categories they heard on the listing and matching tests. Matching could be last, because it was a test for knowledge that could not be acquired by taking the other tests.

Before each classroom teacher showed her class the videotapes, she told the children to try to remember as much information as possible. She told them they would see five videotapes about birds over the week, and they would be tested the following week.

Coding and Scoring

Memory Test

The number of birds correctly recalled from the list of birds was tallied. The criterion used for counting a word was that the child had to pronounce at least one syllable from the word correctly. For example, "whip" was counted for "whip-poor-will." Words were counted only the first time the child said them (i.e., no credit was given for repetitions).

Knowledge Tests

1. Grouping. The labels children gave to their groups of birds were examined. One of three possible designations was given to each label. If the label contained information that clearly was visible from the pictures of the birds (e.g., birds that are black, birds with big feet, birds with small beaks), then that label was considered a "physical description." If the label contained information that was contained in the names of the birds (e.g., birds that end in "bird," birds that begin with "s"), then that label was considered "sound-based." If the label did not contain any information that could be obtained from the picture of the bird or the name of the bird (e.g., gamebirds, petbirds, colorful birds), then the label was considered "meaning-based." The total number of birds a child included in meaning-based groups was tallied. Taught birds and control birds were scored separately for analysis. Independent scorers reached 95% agreement when scoring half of the subjects' data in this manner. In the event of disagreement, a third independent rater scored that child's data. All disagreements were resolved in this manner.

2. Listing. The total number of birds correctly listed under the appropriate categories was counted. Appendix F displays the answers that were considered acceptable and unacceptable for each category. These were determined by an ornithologist. All categories except "talking birds" were

counted. The category "talking birds" was considered the control set, because that category, and the birds contained within it, was not taught by the videotapes.

3. Facts. The number of correct facts children gave for each bird was tallied, and then the scores for all birds were summed. Books about birds (Bull & Farrand, 1977; Peterson, 1947; Robbins, Bruun, & Zim, 1966; Steward, 1977; Zim & Gabrielson, 1956) or an ornithologist were consulted when questions about the truth of certain facts were encountered. The correlation between the scorings of two independent raters of 20 children's data was .97.

Other measures calculated were the number of birds about which children told at least one fact, and the percentage of the total correct facts they told that were of a general, categorical nature, rather than specific in nature. For example, if a child said that a bird "lived by water," "ate animals," or "sang a song," those facts were considered general, categorical statements. On the other hand, if a child said facts such as a bird "lived by the ocean," "ate mice," or "sang its name", those facts were considered specific in nature, and therefore were not counted.

4. Matching. Appendix E displays the scoring key utilized for the matching test. Again, separate scores were obtained for taught birds and the control set of birds.

Clustering

The Adjusted Ratio of Clustering (ARC score) was used as an index of clustering in the children's recall. Roenker, Thompson, and Brown (1971) reported that this measure had the advantage of allowing comparisons of relative amounts of clustering over trials and across experiments, because it reflected the "proportion of actual category repetitions above chance to the possible category repetitions above chance." (p. 45) The formula for the ARC score is provided in Appendix G.

Overt Study Strategies

Because it was important to assess spontaneous strategy use in this study, only overt strategies could be assessed. The two minute study time was videotaped and coded by two independent observers, who reached 88% agreement on whether each of the four categories of study behaviors occurred for a subsample of 40 children (see Appendix H). Four aspects of overt study strategies were coded: involvement with the task of remembering, rehearsal, involvement with the cards, and self-testing. In the event of discrepancy, a third independent rater watched and coded the videotape for that child. All disagreements were resolved in this manner.

Behaviors designated as "strategic" are starred in Appendix H. The presence versus absence of each type of study behavior (coded as "1" if it had at least one checkmark

by a "strategic" behavior and "0" if it did not) was correlated with recall. In addition, a composite strategy score was correlated with recall. A maximum of four points (one for each study strategy category) could be earned toward the composite score that represented total strategy use. This composite score also was utilized to assess whether increases in study strategies occurred after children watched the videotapes about birds.

CHAPTER III
RESULTS

The results are subdivided according to the most important hypotheses of this study. The first main question was whether children's knowledge of birds increased significantly after they viewed the videotapes about birds. In accordance with the design of the study, this question was answered via both within-subject analyses and between-subject analyses. The second important question was whether children's memory, clustering, and strategy use changed significantly after they viewed the videotapes. The current theories about memory development would predict that if knowledge changed significantly, then these measures also should change significantly. Again, the answer to this question was investigated via both within-subject and between-subject analyses. The third and final question was whether there were correlations among knowledge, strategy use, and recall. This relation has been demonstrated by previous memory development research.

Did Knowledge Change?

Within-Subject Analyses

The only children used in the analyses for the within-subject changes in knowledge were the Knowledge Test Twice group (refer to Table 2-1 for the design of the experiment). The means and standard deviations for each test are displayed in Table 3-1.

A z-score was computed for each child on each of the four knowledge pretests by subtracting the mean for that test from the test score a child achieved on that test, and dividing that difference by the standard deviation

TABLE 3-1

Pre-VIDEO and Post-VIDEO Means and Standard Deviations For Each Knowledge Test

Knowledge Test	Pre-VIDEO	Post-VIDEO
GROUPING	13.41 (10.92)	16.95 (12.42)
LISTING	11.59 (4.24)	13.27 (5.23)
FACTS	45.36 (18.98)	38.89 (20.87)
MATCHING	22.09 (3.66)	24.09 (3.74)

Note: All z-scores were computed using the Pre-VIDEO means and standard deviations.

for that test. Second, an average pretest z-score for each child was computed by adding together the child's z-scores for each of the four tests, and dividing the sum by four.

Third, in order to look at possible improvements in knowledge, each child's posttest scores for each knowledge test were converted to z-scores (according to the pretest means and standard deviations so that change would be apparent). Finally, average posttest z-scores for each child were computed in the same manner as for the average pretest z-scores.

To see if the videotapes caused children's knowledge to improve significantly, the overall measures of children's knowledge (z-scores) were compared. An Analysis of Variance (ANOVA) examined the effects of age (2: older versus younger), sex (2), and session (2: pretest versus posttest) on the average z-scores. Session was a within-subject variable. There was a significant main effect of age, $F(1,15) = 6.17$, $p < .05$. Older children had higher z-scores than younger children. More importantly, however, was the fact that z-scores were significantly higher for the posttest than they were for the pretest, $F(1,15) = 19.30$, $p < .001$. Thus, as hypothesized, knowledge of birds improved significantly after children watched the videotapes about birds.

In order to determine whether or not all knowledge tests changed significantly from pretest to posttest, or if some groups improved to a greater extent than others, an ANOVA was computed for each knowledge test separately. Each 2 (sex) by 2 (age) ANOVA had repeated measurements on session (2).

1. GROUPING Test. The ANOVA for the GROUPING test scores revealed significant main effects of age, $F(1,18) = 6.23$, $p < .05$, and session, $F(1,18) = 15.14$, $p < .01$. However, there also were significant interactions between session and age, $F(1,18) = 8.05$, $p < .05$, and session and sex, $F(1,18) = 5.69$, $p < .05$.

Follow-up analyses were conducted to investigate these interactions. ANOVAs were computed for each age separately. Sex was the grouping variable in each, and session was a repeated measurement. Whereas older children improved significantly from pretest to posttest (means were 16.50 and 25.83, respectively), $F(1,10) = 33.97$, $p < .001$, younger children did not (means were 8.70 and 11.10, respectively). Other ANOVAs were computed for each sex separately. Each used age as the grouping variable and session as a repeated measurement. Whereas males improved significantly from the pretest to the posttest (means were 11.67 and 21.33, respectively), $F(1,10) = 22.20$, $p < .001$, females did not (means were 14.50 and 16.50, respectively). Therefore, the interactions were due primarily to older children and males showing more improvement from pretest to posttest in categorizing birds as members of meaning-based groups and less tendency to categorize birds by physical appearance or the sounds of their names.

A parallel ANOVA was conducted using the number of the control set of birds (i.e., those not mentioned on the

videotapes) that were placed into meaning-based groups. Unlike the results for the birds that were taught, no changes occurred for any group in the number of control birds that were placed into meaning-based groups. Thus, it is likely that the increase in the number of taught birds that were placed into meaning-based groups was due to the videotape and not simply an artifact of repeated testing.

2. LISTING Test. The ANOVA that investigated the influence of age (2), sex (2), and session (2) on listing test scores also showed significant main effects of age, $F(1,18) = 5.75$, $p < .05$, and session, $F(1,18) = 84.44$, $p < .0001$. However, there also was a significant three-way interaction between age, session, and sex. Although all groups improved from pretest to posttest, some groups improved more than others (see Figure 3-1). Younger males, $F(1,4) = 8.96$, $p < .05$; younger females, $F(1,4) = 72.00$, $p < .01$; and older males, $F(1,6) = 106.67$, $p < .001$, all were able to list significantly more birds for each category after watching the VIDEO about birds. Although older females were able to list more birds after the VIDEO, they did not improve significantly ($p = .09$). Thus, the three-way interaction in the ANOVA for listing was due primarily to differential improvement within groups.

A parallel ANOVA using only the number of talking birds (i.e., a category about which no information was provided on

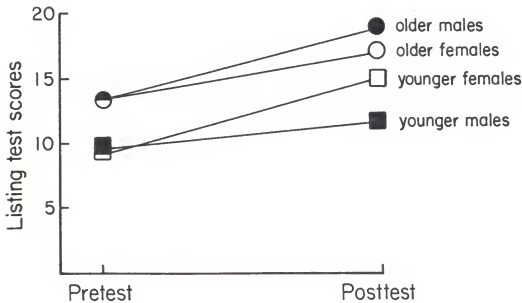

FIGURE 3-1

Pretest and Posttest Listing Test Scores for Older Versus Younger Males and Females

the videotapes about birds) that children listed before and after the videotapes confirmed that no significant improvement occurred in this control measure for any group. Thus, the observed changes in the taught birds probably were not simply an artifact of testing.

3. FACTS Test. The ANOVA for the total number of facts generated for the 45 birds had neither significant main effects nor significant interactions. Children's ability to list facts for birds was not influenced by the videotapes. Likewise, the number of facts known for the control set of birds did not change significantly.

Although the total number of facts known about birds did not change, an analysis was conducted to determine whether the number of birds about which children knew information changed. Did children learn information about birds that they did not know before the videotapes? The number of birds about which children knew at least one fact was counted and used in this ANOVA. This ANOVA also showed no effect of session for any group.

Although the two previous ANOVAs suggested that the number of known birds and the number of facts generated by children remained constant, a final ANOVA was conducted to determine whether the nature of the facts children generated changed as a result of watching the videotapes. The percentage of facts that were general, categorical statements was utilized for this analysis.

The increase in the number of facts that referred to categorical information after children watched the videotapes was striking. The percentage of general, categorical statements children said for the posttest (M = 62.05) was significantly higher, $F(1,15) = 14.70$, $p < .05$, than the percentage for the pretest (M = 43.16). There were no differences among older and younger children or males and females. Thus, the type of facts children said differed in a more qualitative than quantitative manner.

4. MATCHING Test. The ANOVA that investigated the effects of age, sex, and session on matching test scores revealed a significant main effect of session, $F(1,18) = 4.13$, $p < .05$. Children were able to match a significantly larger number of birds with their appropriate categories after watching the videotapes about birds. The means for the pretest and posttest matching tests were 22.09 and 24.09, respectively. On the other hand, the control set of birds showed no corresponding change in the number of correctly matched birds. Again, the change appeared to be due to the videotapes rather than an artifact of testing.

To summarize the within-subject analyses, three of the four knowledge tests had significant improvements from the pretest to the posttest quantitatively. Older children and males improved their ability to group birds by meaning to a greater degree than younger children and females. Older females did not improve their ability to list birds under

appropriate experimenter-designated categories significantly, but the other groups did. Both males and females improved their matching of birds with categories. Although neither the number of birds for which children told facts nor the total number of facts children could generate changed significantly, the nature of the facts children told changed from more specific information about individual birds to more general, categorical information. Therefore, knowledge did improve, especially for older children and males, and in a both a quantitative and qualitative manner.

Between-Subject Analyses

Preliminary ANOVAs were computed to investigate whether there were any differences among the groups on posttest knowledge (i.e., posttest z-scores). In order to safely assume that the pretest scores of the Knowledge Test Only group were representative of children's knowledge of birds, and to generalize the results to standard laboratory tasks (in which children come to the memory task with pre-existing knowledge), it was important to demonstrate that the groups' posttest knowledge scores did not differ. Fortunately, the results confirmed that there were no significant differences among the groups. Therefore, for all between-subject assessments for post-VIDEO knowledge, the Recall Test Twice and the Posttest Only groups' scores were combined. These post-VIDEO knowledge test scores were compared to the pretest

(or pre-VIDEO) scores of the Knowledge Test Only group (refer to Table 2-1 for the design of the study) to assess hypothesized differences in knowledge.

A Multivariate Analysis of Variance (MANOVA) was conducted, looking at the effect of age, sex, and time of testing (2: pre-VIDEO or post-VIDEO, depending upon the group) on the scores for each knowledge test. MANOVA was considered the best analysis, because it takes the correlations among the tests into consideration. There was a significant main effect of age, $F(4,80) = 2.77$, $p < .05$. Overall, older children had higher knowledge scores than younger children. According to the Pillai's Trace statistic, there also was a significant main effect of time of testing, $F(4,80) = 4.53$, $p < .01$. Post-VIDEO scores were higher than pre-VIDEO scores. Thus, these results confirm those of the previously presented within-subject analyses.

In order to determine which of the knowledge tests demonstrated significant improvement, ANOVAs were computed for each knowledge test separately. Every 2 (age) by 2 (sex) by 2 (time of testing) ANOVA showed main effects of age: $F(1,83) = 8.59$, $p < .05$, for grouping; $F(1,83) = 4.95$, $p < .05$, for facts; $F(1,83)$, $p < .01$, for listing, and $F(1,83) = 4.91$, $p < .05$, for matching. Older children's scores were superior to younger children's scores on every knowledge test. The ANOVA for matching also showed a significant main effect of session, $F(1,83) = 5.29$, $p < .05$. Children were

able to match a significantly higher number of birds with their correct categories after they saw the videotapes (pre-VIDEO versus post-VIDEO means were 22.09 versus 24.26, respectively). The ANOVA for grouping revealed a significant interaction between session and sex, $F(1,83) = 4.22$, $p < .05$. Follow-up analyses of this interaction supported the results of the within-subject analyses for grouping. Whereas boys' ability to group birds into meaning-based groups improved significantly, girls' ability did not. Listing did not improve significantly after the videotapes.

The three between-subject ANOVAs investigating the three different measures for the facts test replicated the within-subject analyses precisely. There were no significant differences between pre-VIDEO and post-VIDEO scores representing the total number of facts generated by children or the number of birds for which children knew at least one fact. On the other hand, the percentage of facts that were general, categorical statements was significantly higher for the post-VIDEO ($M = 57.94$) than the pre-VIDEO ($M = 43.16$) test. Thus, grouping and matching knowledge improved from pre-VIDEO to post-VIDEO testing, especially for boys, and children's fact generation changed in a qualitative manner.

Did Recall, Clustering, and Strategy Use Change? Within-Subject Analyses

Analyses for within-subject changes in recall, clustering, and strategy use compared the pretest and posttest scores of the Memory Test Twice group (see Table 2-1 for the design of the study). Current theories of memory development would predict that if children's knowledge of birds improved significantly, then recall, clustering, and strategy use should also improve.

1. Memory Test. Preliminary analyses showed no significant differences between recall of List A or List B. Therefore, children who recalled both lists were combined for subsequent analyses. An ANOVA was computed to assess the effects of age (2), sex (2), and session (2: pretest versus posttest as a within-subjects variable) on the memory test scores. There was a significant main effect of sex, $F(1,39) = 7.16$, $p < .05$, with boys recalling more words than girls, overall. There also was a significant sex by session interaction, $F(1,39) = 10.99$, $p < .01$ (see Table 3-2).

Follow-up ANOVAs looked at the effect of age and sex on recall for each session separately. Whereas boys recalled a significantly higher number of birds than girls on the pretest, $F(1,39) = 19.07$, $p < .001$, there were no differences between boys' and girls' recall on the posttest. Additional follow-up ANOVAs looked at the effects of age and session on recall separately for boys and girls. Despite the fact that

TABLE 3-2

Means (and Standard Deviations) of Pretest and Posttest Recall for Males and Females in the Memory Test Twice Group

Sex	n	Pretest Recall	Posttest Recall
Males	21	9.86 (1.85)	8.86 (2.15)
Females	22	7.36 (2.13)	8.27 (2.64)

only boys gained significantly more knowledge of birds on the grouping test after the VIDEO, and boys' improvement was, at minimum, equal to girls' improvement, it was only the girls who improved significantly on the memory test. This finding was contrary to what would have been predicted by current memory development theories.

2. Clustering. It would not make sense to consider change from below chance clustering (ARC scores less than zero) to chance clustering (ARC scores equal to zero) as improvement. Therefore, for the purpose of analyses of changes in clustering, ARC scores less than or equal to zero were all set to equal zero. A score of zero meant that no identifiable clustering was present in the child's recall. An ANOVA was conducted to investigate the influence of age (2), sex (2), and session (2) on the ARC scores. Although current research debates whether clustering reflects a deliberate strategy or automatically activated associations, the fact that intra-group associations were emphasized in the

videotapes would lead one to predict that clustering would improve after the videotapes, whether or not children were aware of clustering as a strategy. However, this was not the case. There was neither a significant main effect of session nor any significant interactions involving session.

3. Strategy Use. An ANOVA was computed to see if there were any effects of age, sex, and session on children's composite strategy scores (i.e., involvement with the task, rehearsal, involvement with the cards, and self-testing). Appendix H provides the behavioral descriptions for the strategy categories which comprised the composite score. Again, current research would predict such changes when children's knowledge increased. However, the results showed no significant main effects and no significant interactions. Therefore, like clustering, strategy use did not change for any group.

Between-Subject Analyses

As was the case for the knowledge tests, preliminary analyses showed no significant differences among the groups on posttest memory test scores. The only two groups compared were the Memory Test Twice group and the Posttest Only group, because the Knowledge Test Only group did not take the memory test (refer to Table 2-1 for the design of the study). Therefore, for the between-subject analyses, the pre-VIDEO

scores of the Memory Test Twice group were compared with the post-VIDEO scores of the Posttest Only group.

1. Memory Test. Preliminary analyses revealed no significant difference between the memory test scores for children who studied List A versus those who studied List B. Therefore, further analyses did not include list as a variable.

An ANOVA examined the effects of age, sex, and time of testing (pre-VIDEO versus post-VIDEO) on the memory test scores. There were neither significant main effects nor interactions. These results again were contrary to what would have been predicted by current memory development theories.

TABLE 3-3

Means (and Standard Deviations) of Pre-VIDEO and Post-VIDEO Clustering for Younger and Older Children

Age	Pre-VIDEO Clustering	Post-VIDEO Clustering
Younger	.29 (.36)	.06 (.10)
Older	.21 (.25)	.27 (.30)

2. Clustering. The ANOVA that investigated the effects of age, sex, and time of testing on clustering revealed only a significant age by time of testing interaction, $F(1,67) = 4.26$, $p < .05$ (see Table 3-3). Contrary to the expected improvement in clustering predicted by current theory, the

interaction was due to the significant decreases in clustering by younger children after the videotapes, $F(1,30) = 4.52$, $p < .05$. The older children's clustering remained unchanged by the videotapes.

3. Strategy Use. Supporting the within-subject analyses of strategy use, the ANOVA that investigated the influence of age, sex, and time of testing on children's overt strategy use showed neither significant main effects nor significant interactions. This, too, was contrary to what would have been expected by current theory.

Individual-Subject Analysis of Changes in Knowledge and Memory

Because group means do not always accurately reflect the performance of individuals, an individual-subject analysis of changes from the pretest to the posttest for all knowledge tests and the memory test was conducted. This analysis was expected to reveal whether the significant changes in pretest to posttest scores were due to a substantial number of children's test scores improving, or if they were due only to a few children who improved substantially. An individual-subjects analysis also was expected to reveal whether the lack of significance for the memory test was due to few subjects improving, or whether most subjects improved but only by a few points. Table 3-4 reveals that at least 50% of the younger children's scores improved for every knowledge

TABLE 3-4

Individual-Subject Analysis for Patterns of Changes on the Knowledge and Memory Tests by Age

Direction of Change from Pretest to Posttest	AGE Younger[a]	Older[b]
Improvement		
Grouping Test	20 (15.50)	100 (9.30)
Listing Test	90 (4.56)	92 (5.91)
Facts Test: Total	60 (11.50)	22 (15.00)
Facts Test: Number	60 (4.67)	78 (4.14)
Facts Test: Type	100 (16.79)	78 (27.01)
Matching Test	50 (2.60)	58 (3.86)
Memory Test	43 (2.10)	33 (2.00)
Same Score		
Grouping Test	40	0
Listing Test	10	0
Facts Test: Total	0	0
Facts Test: Number	20	0
Facts Test: Type	0	11
Matching Test	10	17
Memory Test	24	33
Regression		
Grouping Test	40 (4.25)	0
Listing Test	0	8 (3.00)
Facts Test: Total	40 (11.25)	58 (5.86)
Facts Test: Number	20 (3.50)	22 (6.00)
Facts Test: Type	0	11 (5.20)
Matching Test	40 (1.25)	25 (2.00)
Memory Test	33 (2.90)	33 (1.70)

Note: Numbers reflect the percentage of children at each age whose pretest to posttest scores were in the stated direction. The average improvement or regression for the group is in parentheses.

[a] n = 10 for the knowledge tests and n = 21 for the memory test.

[b] n = 12 for the grouping, listing, and matching tests, n = 9 for the facts test, and n = 21 for the memory test.

test measure except grouping, and at least 50% of the older children's scores improved for every knowledge test measure except the total facts generated. Especially noteworthy were the improvements by 100% of the younger children (an average of 16.79 percent) and 78% of the older children (an average of 27.01%) on the percentage of generated facts that referred to general, categorical information.

In contrast to the knowledge tests, the pattern for the memory test appeared to be due more to chance variation than to consistent but small improvements by the majority of children. There were approximately two points difference between pretest and posttest scores on the average for both children showing improvement and children showing regression on the memory test.

Were There Significant Correlations Among Knowledge, Clustering, Strategy Use, and Memory?

Correlations were computed between each of the knowledge test scores, clustering (ARC scores), or composite strategy use scores, and the memory test scores for younger children, older children, and all children (see Table 3-5). Although the correlations between each knowledge test and recall were significant for the sample as a whole, the correlations were higher for older than for younger children. Multiple regression analyses were computed for post-VIDEO memory test scores as a function of the four knowledge tests for each age

TABLE 3-5

Post-VIDEO Correlations Between Knowledge, Clustering, or Strategy Use and Recall for Groups of Children

Measure Correlated With Recall	Younger Children (n=31)	Older Children (n=41)	All Children (n=72)
GROUPING	.26	.28	.29*
LISTING	.29	.47**	.43***
FACTS	.26	.42**	.38**
MATCHING	.17	.34*	.30*
CLUSTERING	.58*	.21	.39*
STRATEGY USE	.31	.06	.17

*$p<.05$
**$p<.01$
***$p<.001$

separately. Whereas the four knowledge tests explained 26% of the variation in older children's memory test scores, they only explained 6% of the variation in younger children's memory test scores. Therefore, knowledge of an area becomes a better predictor of memory with age.

As Table 3-6 shows, the correlations among the four knowledge tests all were higher for older children, with the exception of those between listing or matching and facts (which were each .02 higher for younger children). The largest discrepancy between older and younger children's correlations was between the listing and facts tests. Thus, older children's knowledge is more inter-related than younger children's.

TABLE 3-6

Correlations Among the Knowledge Tests By Age

Knowledge Test Correlated With	YOUNGER CHILDREN		
	LISTING	FACTS	MATCHING
GROUPING	.57	.60	.41
LISTING		.51	.42
FACTS			.42
Knowledge Test Correlated With	**OLDER CHILDREN**		
	LISTING	FACTS	MATCHING
GROUPING	.66	.58	.52
LISTING		.64	.47
FACTS			.40

To determine whether clustering predicted recall, two Analyses of Covariance (ANCOVA) were computed. Each investigated whether clustering predicted recall, while controlling for differences in age and sex. The results for the ANCOVA that investigated pre-VIDEO clustering were that there was a significant effect of clustering, $F(1,38) = 4.60$, $p < .05$. Children who had more clustering in their recall remembered more words. The three variables in this analysis explained 38% of the variation in recall scores. It is interesting to note that sex was still significant (as discussed in the within-subject follow-up tests for the sex

by trial interaction on the recall measure), even when age and clustering were controlled. However, there were no significant age differences in recall. The results of the ANCOVA that investigated post-VIDEO recall also had a significant effect of clustering, $F(1,71) = 10.24$, $p < .01$, controlling for differences in age and sex. Again, higher clustering was associated with better recall, and the three variables explained 17% of the variation in recall scores. The results showed no effects of sex or age. Therefore, clustering did predict recall, as one would expect.

CHAPTER IV
DISCUSSION

Summary of the Results

The hypothesis that knowledge would increase from the pretest to the posttest was supported by both within- and between-subject analyses. This increase, however, did not occur in all subject groups on all assessments of knowledge. All children significantly improved their ability to match birds with their correct categories after seeing the videotape about birds. However, for the grouping test, the change was significant only for boys. That is, girls did not significantly improve their ability to place birds into meaning-based groups. In addition, older girls did not significantly improve the number of birds they could list for each category.

The only knowledge test that did not show improvement quantitatively was the facts test. Two different measures (i.e., the total number of facts children could generate for the birds and the number of birds for which children knew at least one fact) did not improve after children saw the videotapes. In fact, the post-VIDEO means were slightly lower than the pre-VIDEO means. However, the nature of the

generated facts changed. Whereas few responses for birds contained general, category information during the pre-VIDEO test, a significantly higher percentage of the facts said during the post-VIDEO test contained that type of information. This change was evident for both within- and between-subject analyses. Because the pictures of the birds were not visible for this test, as they had been in the Chi and Koeske (1983) study, it was unnecessary to distinguish between facts directly related to the picture and facts not observable from the picture.

With respect to the second hypothesis, despite significant increases is knowledge, there were no corresponding improvements in memory, clustering, or strategy use. Although there were significant differences in knowledge between older and younger children, there were no age differences in recall. Boys did not improve their recall after seeing the videotape about birds, even though they clearly gained more knowledge about birds than girls. Girls also did not improve their recall according to the between-subject analysis but did on the within-subject analysis. Because there was so much fluctuation (i.e., both progressions and regressions) on the memory test, according to the individual-subject analysis, there is not a lot of evidence to indicate positive change. Only two younger females and two older females had recall scores that changed more than two points. Clustering and strategy use did not

improve for any group. Therefore, knowledge improvements did not translate into better strategy use or memory, contrary to the predictions of current theories of memory development. This suggests that improvements in knowledge either are not necessary for improvements in memory with age, or that knowledge is necessary, but not sufficient, for the improvement.

With respect to the third hypothesis, consistent with previous studies which were correlational in nature, each knowledge test had a positive correlation with the memory test. Older children's knowledge and memory had slightly higher correlations than did younger children's.

The results of the present study are important because they raise certain questions that might lead to a clearer specification of the relation between knowledge and memory. Previous research that credits knowledge as being responsible for the major changes in memory with age has been criticized for using the term knowledge too globally and ambiguously (Saarnio, 1987). In contrast, this study included four different assessments of knowledge and thus could provide a more refined description of knowledge. Each of the four knowledge tests presented a slightly different picture of the relation between knowledge and memory. Thus, all assessments of knowledge are not equal, and it is important for future studies to include several measures of knowledge.

The fact that the correlations between knowledge and

memory increased with age supports the suggestion from previous research that categorical information is utilized for mnemonic activities to a greater extent by older children than younger children. The younger children appeared to be more influenced by salient names or perceptual features. For example, practically every third grader recalled the birds lovebird and titmouse, perhaps because of salient associations. Yet, these same children knew nothing about those birds, and they tended to group them together with the cardinal and bluejay, labeling the group "birds with things on top of their heads," a characteristic clearly visible from the pictures of those birds. Although very few older children knew information about those same birds, they also rarely recalled them.

In conclusion, when the present study looked at the relation between knowledge and memory at one point in time, it replicated the previously documented correlation between knowledge and recall. However, a different picture emerged for the group comparisons in the present study that examined the effect on recall of constructing new knowledge, a comparison that was not possible in previous studies because they did not include this manipulation. Improvement in knowledge did not lead to increased recall. That new associations between birds and their category membership were created was apparent from the increases in post-VIDEO knowledge test scores. Yet, like many studies showing that

younger children "have" the available knowledge but do not utilize it, a common finding in research on the production deficiency, the children in this study apparently did not use the new knowledge to enhance their study strategies, clustering, or recall. Thus, this study suggested that acquiring new knowledge may not guarantee its access.

Given evidence for correlation but not causality, the next question logically becomes "Why?". Interpretations of the data will be discussed in the next section.

Why Correlation But Not Causality?

There are two main explanations for why increases in knowledge did not lead to increases in recall. One has to do with the restructuring of knowledge and the other involves speed of activation of related information.

One possible explanation for why the new knowledge was not accessed is that although the children acquired the associations between the birds and their categories, they did not restructure that knowledge into a usable form. Chi argues that having categorical associations is not the same as having a semantic structure (Chi & Ceci, 1987). Although intra-group associations were taught in the videotapes and learned by children in the present study, the children may not have acquired a class inclusion relation (i.e., that all birds in a category simultaneously have certain characteristics and are members of the category and, at the

same time, are part of a larger category, birds). As a result, they might not have had access to all the birds within a category simultaneously. In this case, children may not spontaneously generate category labels and use them to generate category members. Therefore, this explanation for the results would claim that knowledge may need to be in a particular form to become accessible. In other words, quality of knowledge, as well as quantity, is important. With further exposure to information about birds, children might have reorganized their knowledge so that it would have become more accessible to them.

More specifically, knowledge could be structured to be more accessible in the following way. Knowledge may initially be represented in linear associations, next in multiple associations, and finally in hierarchically organized associations. If any associations initially were simply linear, then activating any member of the pair would only activate the other member. Eventually, interconnections among items would increase so that knowledge would be represented as a network. Take, for example, the analogy of a spider web, where each item may be connected to many other items, but the network itself is fragile. Activating any part of the structure would make accessing any other part of the structure more likely, but the whole structure still would not be interconnected. At this point, children are unlikely to generate a category name and use it as a cue for

retrieving birds. Eventually, as a greater and greater number of associations between birds are established, and previous associations become stronger, the form of knowledge might change to become a hierarchical structure. The members would be perceived as a unit--one of several units of the bird kingdom. Activation of any part of the structure would simultaneously activate all the other parts; recalling any single bird should activate the entire structure and lead to the accessing of all birds in that category. Knowledge is easily accessed, for one need only retrieve the whole structure.

Thus, according to this position, memory development would be the result of both qualitative and quantitative changes in the structure of knowledge. These structural changes would make knowledge more accessible. Using the above analogy, perhaps knowledge was changed to a form similar to the spider web for many children in the present study. They were able to list more birds for categories and could group a larger number of birds with self-titled meaning-based categories. They generated a higher percentage of general, categorical facts after watching the videotapes. Thus, they had more than single, linear associations. However, they may not have been able to retrieve the whole structure easily.

A second possible explanation is that the created knowledge was not accessed because the exposure to the

videotapes did not increase the speed at which the new knowledge could be activated, perhaps because of the way the information was taught. During the videotapes, associations between birds were taught. In an effort to equate the teaching of all birds, no more than two birds from the same category ever were compared with any other bird in that category. Therefore, all the new associations received equal attention, and probably had equal strength.

Perhaps for knowledge to be utilized, some pathways need to be traveled more frequently, thus creating stronger routes to knowledge rather than simply additional pathways to that knowledge. Bjorklund (1987) claims that increases in the frequency of occurrence of items probably cause an increase in the number and type of features and create more links with other items in semantic memory. However, the results of this study suggest that simply creating more links (by teaching facts about birds) does not appear to be sufficient, and although the number of links from categories to birds or birds to categories increased in this study, that too was not sufficient for improved memory. Perhaps frequent exposure to items is necessary so the links between items become well-practiced, and it is only after the information can be activated more readily that knowledge is utilized. More specifically, repeated exposure to swans, geese, and ducks in the context of water may result in water and the names of

these birds immediately becoming activated when any single bird is recalled or encountered.

The correct answer to "What is memory the development of?" might be "knowledge, ease of access, and strategies, in that order of acquisition." This answer would suggest that knowledge and ease of accessing that knowledge are precursors for strategy development, and that increased strategy usage, particularly strategies that tie the material to be learned with prior knowledge, is what increases memory performance. More specifically, memory development might proceed as follows: First, perhaps some knowledge of the area is acquired. This foundation of knowledge might be necessary as a first step. In this study, children appeared to acquire categorical knowledge mainly about those birds for which they had previous information. Evidence is that the number of birds for which they generated facts did not change but the type of facts they generated changed significantly (i.e., referred to more general, categorical information). Second, repeated experience with the knowledge may strengthen semantic grouping connections and weaken other facts, such as perceptually-based facts. The outcome is a categorical organization with knowledge structured in a more usable form and/or with faster speed of activation of related information. Third, easier access or faster activation means that more sophisticated study strategies can be utilized, because semantic relations are easily accessed. With few

exceptions, the body of research in cognitive psychology confirms the superiority of performance on free-recall tasks when the information is encoded semantically.

Either of the above explanations (i.e., structural or speed changes), or perhaps some process unexplored here, taken as intermediate steps between knowledge and memory, would explain why having the knowledge is not sufficient for improvements in strategy use or recall. Early research generated by the hypothesis that younger children had a production deficiency claimed that younger children had the relevant categorical knowledge that could help them recall but tended not to use it. The claim here is that one reason for a production deficiency is that knowledge that cannot be accessed readily due to its primitive structure or its slow speed of activation will not be utilized. These accounts also explain why preschool children only use strategies when involved with very familiar material.

In other work on strategies (e.g., Gobbo & Chi, 1986; Ornstein & Naus, as cited by Zembar & Naus, 1985a), those who already can access knowledge readily (experts) are compared with those who cannot (novices). Studies by Bjorklund and others (Bjorklund & Thompson, 1983; Buchanan & Bjorklund, 1988) compare very familiar knowledge (typical items) with moderately familiar knowledge (atypical items). Studies by Lindberg (1980) and Zembar and Naus (1985b) compare knowledge that is very familiar (or very salient) for one group with

knowledge that is unfamiliar for that group. All of these studies find increased use of strategies associated with the former type of knowledge in the contrasted pair. However, it can be argued that it is not simply a difference in knowledge per se, but the likely differences in either the structure of knowledge, the speed of activation of related knowledge, both, or a factor unexplored here, that actually contributed to the observed increased use of strategies.

In addition, it should be noted that Bjorklund's comparisons of typical and atypical items contrast two types of knowledge that both, for the most part, are at the upper end of the continuum. Most people do not name watermelon as the first response when asked to list pieces of fruit, but readily would agree that it is a member of that category, and they might name it readily during certain months of the year. Therefore, although subjects' knowledge differs with regard to the structure of categories or the speed of activation of their atypical members, minimal training would be necessary to facilitate the subjects' ability to access it. That would not be true in the present study, which examines moderate levels of knowledge.

It might be argued that including a larger number of subjects or identifying and removing artifacts of measurement might reveal a significant change in recall. If the lack of improvement in recall were due only to too few subjects, then the knowledge tests should have been influenced as well. In

fact, a greater number of subjects took the memory test twice than the knowledge tests twice, so the statistical test for changes in memory actually had more power. Furthermore, the individual-subject data analysis revealed entirely different patterns of results for the knowledge and memory tests. Whereas the knowledge tests clearly showed that a majority of the subjects improved (especially older children, almost all of whom improved somewhat), the recall test showed that almost equal numbers of children had scores that increased, decreased, or stayed the same. Furthermore, the majority of children's pretest and posttest recall scores were within one point of each other. Finally, the lack of improvement in the recall of males was not due to a ceiling effect. They recalled only an average of 9.86 of the 20 possible words on the pretest. Therefore, they had adequate room for improvement.

In an effort to generalize the results with certainty to those of correlational studies, a design was used in which no child took all the tests. However, that prevented the within-subject measurements of both knowledge and memory for the same children. The fact that the three conditions did not differ on any test suggests that children can take all the tests in future research without introducing practice effects or sacrificing the generality of the results.

Other Issues and Future Research

In this first experimental (not simply correlational) investigation of the relation between knowledge and memory, care was taken not to present knowledge in such a way that any changes in memory would appear to be trivial. A main consideration for designing the instruction about birds was that it was desirable to focus on two changes in specific aspects of knowledge identified as important for memory in previous research. One was creating a larger number of intra-group associations, which was the major characteristic that separated the well-known and less-familiar dinosaurs known by a boy in the study by Chi & Koeske (1983). The other was changing children's focus upon physical characteristics to a focus on meaning-based characteristics, labeled explicit and implicit propositions by Gobbo & Chi (1986), and found to distinguish experts from novices. This previous research suggested that these changes in knowledge would be sufficient for changes in memory. The results of this study indicate that these knowledge differences alone may not be the cause of improvements in memory. Thus, future research should attempt to specify the nature of the relation between knowledge and memory more clearly.

In particular, future research should investigate the possibilities that restructuring of knowledge or changes in the speed of activation are intermediate steps to improvement in memory. The structure of knowledge purposefully was not

taught directly. That is, the videotapes did not present a category name and then list all of the birds in that category. Children neither saw all the birds belonging to a category at once nor were given the labels for all the different categories at one time. Therefore, any changes in memory would not be trivial. As in real life, children had to do some construction of any hierarchical knowledge about birds and categories. The fact that increased knowledge did not bring increased recall suggests that the necessity to construct the categorical knowledge was too effortful for children to do for birds about which they had little prior information or experience. It would be interesting to determine whether children would learn new birds more readily if they were provided with the hierarchy of categories from the outset. Giving children that structure before they saw the videotapes might facilitate their acquisition of a knowledge structure, even if the birds were taught randomly, as they were in this study.

One important aspect of knowledge acquisition may be that members of a category be encountered in the same context or at about the same time. To determine whether proximity of learning is an important cue for restructuring knowledge, the lessons about birds could be rearranged for one group of children to see if that facilitated their later use of that knowledge for recall. The lessons about all the birds from one category would appear consecutively, instead of being

interspersed with birds from other categories. In the real world, learning generally occurs either in the same physical context or within a time context. For example, children encounter swans, ducks, and geese at the lake (physical context), or children may hear a whip-poor-will, a chuck-will's-widow, or an owl at about the same time on different nights (a time context). The children still would need to do some construction of a knowledge structure, because the birds would not be explicitly identified as belonging to a category, and the nature of that category would not be explained. Research also could examine the argument that speed of access of knowledge is what is important. Perhaps training children on half the number of birds, thus spending twice the amount of time on each, would facilitate recall.

Another approach for future research is to use other tasks. For example, a task similar to the clue game (the child and experimenter take turns giving properties and identifying the "creature") utilized by Chi and Koeske (1983) might be attempted with a small number of children both before and after training. Assessment of the structure of children's knowledge might include a traditional Piagetian class-inclusion task. Then the probabilities of trained versus untrained birds being represented hierarchically could be compared.

Because an important part of this initial study was to look at children's spontaneous strategy use, it was decided

to record spontaneous overt strategies rather than to elicit particular strategies from children. Like other studies that infer strategy use from overt behaviors, precision of measurement often is sacrificed. For example, because very few children rehearsed aloud, the definition of rehearsal also included obvious lip movement, obvious head-bobbing, or any combination of the two. Therefore, some children could have been rehearsing covertly, but were not classified as such because they produced no observable indicators. Spontaneous strategy use actually was quite low, so the next step would be to instruct children to use strategies. With this design, increases in knowledge may lead to increased ability to profit from this instruction.

One example of elicited strategies from children would be having children sort the birds for recall. A comparison of the well-trained versus untrained birds would be made. Would children be more likely to group the well-trained birds by meaning, and consequently to recall those particular birds better?

Another series of studies could investigate whether changes in the speed of activation alone were necessary for improved strategy use and memory. Children would receive practice identifying the appropriate category for half of the items on a list of birds. The pretest and posttest memory test would include a measurement of the style and content of the children's rehearsal (which they would be asked to

perform aloud). Comparisons would be made of the trained versus untrained items. Would children be more likely to include the trained than the untrained items in their rehearsal sets? Would their rehearsal become more active and contain a greater number of items from the same category when they could access the items and category information more readily?

The results of the present study challenge current views of the relation between knowledge and memory development. The question of "What is memory the development of?" is far from answered, and it is time to rethink the old answers, redefine possible mechanisms for change, clarify old theories, or invent and test new ones. In particular, it is crucial that researchers attempt to a) define and measure knowledge with multiple tests and b) conduct more experimental tests in which new knowledge is created. Both are virtues of the present study.

APPENDIX A
LISTS OF BIRDS USED FOR THE MEMORY TEST

LIST A

Birds of Prey
hawk
kite
osprey

Birds People Eat
chicken
goose
pheasant

Talking Birds
parrot
lory
cockatoo

Birds Awake at Night
whip-poor-will
nighthawk
mockingbird

Birds that Live by Water
oystercatcher
tern
plover
swan

Songbirds
bluebird
robin
chickadee
goldfinch

LIST B

Birds of Prey
eagle
buzzard
vulture

Birds People Eat
turkey
grouse
quail

Talking Birds
parakeet
lovebird
monk

Birds Awake at Night
chuck-will's-widow
nightingale
owl

Birds that Live by Water
gull
heron
sandpiper
snakebird

Songbirds
bluejay
cardinal
sparrow
titmouse

Control
blackbird
kestrel
mynah
starling
swallow

APPENDIX B
ORDER OF LESSONS PRESENTED ON THE VIDEOTAPES ABOUT BIRDS

Day 1 (17 minutes)
General Introduction
Introduction to Water Birds
Trumpeter Swan
Introduction to Songbirds
Tufted Titmouse
Ring-Billed Gull
Carolina Chickadee
Introduction to Birds People Eat
Canada Goose
Cardinal
Wild Turkey
Killdeer Plover
Prey

Day 2 (12 1/2 minutes)
Robin
Sanderling Sandpiper
Chipping Sparrow
Introduction to Birds Awake at Night
Great-Horned Owl
Eastern Bluebird
Whip-poor-will

Day 3
Royal Tern
Bluejay
Great Blue Heron
American Goldfinch
American Oystercatcher
Chuck-will's-widow
Snakebird

Day 4
Bantam Rooster (chicken)
Nighthawk
Introduction to Birds of Prey
Swallow-tailed Kite
Ruffed Grouse
Bald Eagle
Ring-necked Pheasant

Day 5
Sharp-Shinned Hawk
Bobwhite Quail
Red-tailed Hawk (Buzzard)
Nightingale
Osprey
Mockingbird
Turkey Vulture

APPENDIX C
SAMPLE LESSONS FROM THE VIDEOTAPES ABOUT BIRDS

Royal Tern

Like the sandpiper and the plover, a tern lives near the beach. In fact, it only lives near salt water, never near lakes or rivers like some other water birds.

Unlike the sandpipers, terns spend most of the daylight hours in the air flying, and they're clumsy on land. You won't find terns running up and down the beach the way sandpipers do. Tern's long tails help them to make quick turns to the right or left when they are flying.

The Royal Tern is a large tern with a heavy orange-red bill, black cap, pale gray back and wings, white forehead and black crest. Their tail has a slight fork (or V) in it. The Royal Tern's wings are long and narrow, like the plover's wings are.

When terns search for food, they fly over the water with their bill pointed downward. Then they dive into the water from the air to catch fish. Royal Terns eat only fish.

There's usually not much material for a nest at the seashore. Few plants can grow in loose sand that's constantly stirred and shifted by wind. So, many kinds of seashore-dwelling birds (such as the Royal Tern) either lay their eggs right on the sand or else scoop out a slight hole (like the sandpiper does) and lay their eggs in that. The eggs of many seashore birds are splotched and streaked with color that makes them look like a bunch of pebbles. Thus, although the eggs are right out in the open, they're well hidden by blending in with the beach. So, like plovers, terns have a clever way to protect their young!

American Goldfinch

Unlike the noisy, screaming, poor songs of the bluejay, the goldfinch sings a bright song "per-chick-o-ree." As it flies, it also sings a song in time with the beat of its wings. That song sounds like "potato-chips."

The male and female bluebirds and bluejays are similar. Not so for the American Goldfinch. In fact, the American Goldfinch even looks different in the summer and winter.

In the spring and summer, the male is bright yellow with white edges on black wings and tail and a black forehead. In the winter the male looks more like the female: dull yellow, brown with wing bars and no black on their heads. Goldfinches are much smaller than bluebirds or bluejays.

You can recognize a Goldfinch when it's flying, because it flies like a roller coaster---up and down---and up and down.

The goldfinch's main food is seeds. It especially likes tiny seeds, so it has a little pointed bill to help it get weed seeds, small grain, and some wild fruit. Because weed seeds aren't available until late summer, baby Goldfinches hatch much later than other birds like the bluebird and bluejay. Goldfinches wait to lay eggs so they will have lots of food for their babies.

The goldfinch is often called the "wild canary", because of its yellow color and clear song.

Nighthawk

The nighthawk's name tells you one time of day that you will find it flying. Can you guess when that is?

Yes, like the chuck-will's-widow and the whip-poor-will, nighthawks are birds that can be heard during the night. It repeats a buzzy "beans, beans, beans." The nighthawk is different from the chuck-will's-widow and the whip-poor-will though, because it often flies in the sunlight, too.

The nighthawk is not a hawk. It's actually a close relative of the whip-poor-will and is the same size, too. You can tell the nighthawk and whip-poor-will apart, because the nighthawk is darker and has a longer tail that has a fork (or V) at the end. It has a white patch on its wings, too. It also doesn't spend most of its time on the ground like the whip-poor-will and chuck-will's-widow. Instead, it is constantly in the air, flying in a zig-zag pattern, circling, diving, and banking.

It catches flying insects on its wing like the whip-poor-will does. It also flies with its short-billed mouth wide open. In one single day, one nighthawk ate over 500 mosquitoes and another one ate 2175 flying ants! The next time you're out at night getting bitten by mosquitoes, try to find a nighthawk to get rid of those pests!

APPENDIX D
LISTS OF BIRDS FOR THE FACTS TEST

swan	bluejay	nightingale
sparrow	kite	monk
mynah	starling	heron
quail	parrot	goose
cardinal	osprey	chickadee
chicken	swallow	eagle
goldfinch	whip-poor-will	titmouse
mockingbird	gull	cockatoo
blackbird	buzzard	snakebird
vulture	parakeet	owl
oystercatcher	grouse	turkey
bluebird	lovebird	lory
chuck-will's-widow	sandpiper	kestrel
plover	robin	pheasant
hawk	nighthawk	tern

APPENDIX E
SCORING FOR THE MATCHING TEST

1 = Birds of Prey
2 = Birds People Eat
3 = Talking Birds
4 = Birds Awake at Night
5 = Birds that Live by Water
6 = Songbirds

bluebird	6	tern	5	owl	4
plover	5	pheasant	2	osprey	1
chuck-will's-widow	4	swan	5	parrot	3
hawk	1	mockingbird	4 or 6	starling	6
blackbird	6	goldfinch	6	kite	1
vulture	1	chicken	2	swallow	6
oystercatcher	5	quail	2	whip-poor-will	4
cardinal	6	mynah	3	gull	5
eagle	1	sparrow	6	buzzard	1
titmouse	6	lory	3	lovebird	3
cockatoo	3	kestrel	1	grouse	2
chickadee	6	bluejay	6	sandpiper	5
goose	2 or 5	turkey	2	parakeet	3
heron	5	nightingale	4 or 6	robin	6
monk	3	snakebird	5	nighthawk	4

APPENDIX F
SCORING OF THE CATEGORY LISTING TEST

1) BIRDS OF PREY OR BIRDS THAT EAT ANIMALS

Acceptable Answers: hawk, vulture, eagle, kestrel, osprey, kite, buzzard, snakebird, gull, oystercatcher, heron, tern, owl
Unacceptable Answers: nighthawk, titmouse, quail, bluejay, sandpiper, duck

2) BIRDS THAT PEOPLE EAT

Acceptable Answers: goose, pheasant, chicken, quail, turkey, grouse, dove, duck
Unacceptable Answers: sparrow, titmouse, wren, any other songbird

3) TALKING BIRDS

Acceptable Answers: cockatoo, monk, mynah, lory, parrot, lovebird, parakeet, macaw
Unacceptable Answers: whip-poor-will, chuck-will's-widow, chickadee, mockingbird, cardinal, canary

4) BIRDS THAT ARE AWAKE AT NIGHT

Acceptable Answers: chuck-will's-widow, whip-poor-will, mockingbird, nightingale, owl, nighthawk
Unacceptable Answers: starling, chickadee, osprey, bat

5) BIRDS THAT LIVE BY THE WATER

Acceptable Answers: plover, oystercatcher, goose, heron, tern, swan, snakebird, gull, sandpiper, stork, crane, coot, flamingo, egret, duck, pelican
Unacceptable Answers: turkey, quail, swallow

6) SONGBIRDS

Acceptable Answers: bluebird, blackbird, cardinal, titmouse, chickadee, mockingbird, goldfinch, sparrow, bluejay, nightingale, starling, swallow, robin, canary
Unacceptable Answers: whip-poor-will, chuck-will's-widow, lovebird, parrot, quail, crow, owl, lory, dove, hummingbird, parakeet, killdeer, pigeon

APPENDIX G

FORMULA FOR THE ADJUSTED RATIO OF CLUSTERING (ARC) MEASURE IN ROENKER, THOMPSON, AND BROWN (1971)

$$ARC = \frac{R - E(R)}{\max R - E(R)}$$

where

R = total number of observed category repetitions (i.e., the number of times a category item follows an item from the same category),

max R = maximum possible number of category repetitions,

and

E (R) = expected (chance) number of category repetitions.

It should be noted that

max R = N - k,

where N = total number of items recalled,

and k = number of categories represented in the recall protocol.

And, (from Bousefield & Bousefield, 1966, as cited by Roenker, Thompson, & Brown, 1971)

$$E(R) = \text{Sigma}_i \frac{n_i^2}{N} - 1$$

where

n_i^2 = number of items recalled from category i, and N is as before. (p. 46)

APPENDIX H
STUDY STRATEGY CATEGORIES AND THE BEHAVIORAL DEFINITIONS

Involvement With the Task

____ * leaned forward

____ * stood up

Rehearsal

____ * lips moving

____ * bobbed head up and down (at least two times consecutively)

____ * said the names of birds aloud

Involvement With the Cards

____ pointed at cards (no contact made)
< 5 * 5 - 10 * > 10

____ touched the cards (contact made but the positions of cards unchanged)
< 5 * 5 - 10 * > 10

____ moved the cards (contact made and positions of cards changed)
* < 5 * 5 - 10 * > 10

Self-Testing

____ * looked up > 1 second in duration

____ * looked to the side > 1 second in duration

____ * closed eyes > 1 second in duration

____ * covered the names of birds with hand

Note: Starred items were considered "strategic." Children received one point for each of the four strategy categories that had at least one starred item checked or circled. Then the points were summed to obtain a composite strategy score (maximum = 4).

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BIOGRAPHICAL SKETCH

Darlene DeMarie Dreblow was born in New York, but she never considered herself a "New Yorker." She earned a BA from Marietta College in 1974, an MEd from Ohio University in 1978, an MS from the University of Florida in 1985, and will be receiving her PhD from the University of Florida in 1988, but she currently is not a student. She loved teaching elementary school children (looking forward to every day when she taught first grade, second grade, and learning disabilities for seven years) but left to attend graduate school anyway. After striving to achieve a "mellow" existence for many years, Darlene broke the life-events record during graduate school.

Darlene hates the cold but currently lives in Cambridge, Ohio. She lives on a 98-acre farm, but she is not a "farmer." She teaches at a small, liberal arts college (Muskingum College in New Concord, Ohio), but she plans to remain active in research. She has a family but rarely has time to be a "mother" or a "wife."

These ironies in life have been inevitable. Hopefully, they have strengthened Darlene for her pursuit for harmonious relations among self, soul, and situation in the future.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Patricia H. Miller, Chairperson
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Scott A. Miller
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This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1988

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